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Assessing the Role of Connectivity Indicator in the Sustainable Urban Development of Erbil City

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Abstract

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This study examines urban connectivity as a key indicator of sustainable urban development, focusing on Slava City, a gated residential community in Erbil, Iraq. A mixed-methods approach was adopted, combining Space Syntax analysis (DepthmapX), field observation, and a structured survey of 310 residents to assess both spatial and perceptual dimensions of connectivity. The findings reveal that the gated layout, limited access points, and internal street blockages reduce connectivity and integration, negatively affecting walkability, accessibility, and social interaction. Scenario-based analysis shows that opening side gates improves spatial integration, permeability, and network continuity. These results are paralleled by residents' responses, which indicate a strong perceived improvement in movement and access to services. The study underscores the importance of street configuration and permeability in creating more inclusive and efficient urban environments and offers practical design recommendations for improving connectivity in gated developments in rapidly urbanizing cities.
Keywords: Connectivity; Gated Communities; Urban Sustainability; Erbil.

1. Introduction

Cities are experiencing rapid growth, generating increasingly complex demands for efficient, accessible, and inclusive urban environments that can support sustainable development. Urban sustainability has evolved substantially over recent decades, and scholars have proposed a range of indicators to evaluate how effectively urban form responds to environmental, social, and spatial challenges (Jabareen, 2006; Jenks & Jones, 2010). Assessing such indicators helps reveal how urban settings perform in terms of social equity, ecological balance, and spatial efficiency. In this regard, Neuman (2005) argued that integrating sustainability indicators into urban analysis enables planners to identify strengths and weaknesses in urban form and to guide more effective design interventions, particularly in rapidly growing cities. Among these indicators, urban connectivity is particularly important because it reflects the configuration and interrelationship of streets, routes, and pathways that shape movement, accessibility, and spatial integration within the city (Nel et al., 2018). Connectivity has also been increasingly linked to broader sustainability outcomes. Recent studies show that combining connectivity with green infrastructure indicators can strengthen not only mobility and accessibility, but also microclimatic resilience and ecological performance in hot urban environments (Mobaraki et al., 2025). Similarly, sustainable mobility frameworks identify connectivity as a key component alongside congestion reduction and energy efficiency in evaluating urban performance across different socio-economic contexts (Castro Sánchez & Delgado Ramos, 2025).

Despite the growing body of research on connectivity and sustainable urban development, limited attention has been given to how gated residential compounds in rapidly urbanizing cities affect spatial integration, accessibility, and social interaction when assessed through both configurational analysis and residents' perceptions. This gap is particularly relevant in Erbil, where gated developments have expanded rapidly and often contrast sharply with the city's more permeable traditional urban fabric. Slava City was selected as a representative case study because its enclosed layout, limited access points, and internal street barriers provide a clear example of the spatial challenges associated with gated urban form. Examining the connectivity limitations of this development can therefore contribute to a better understanding of how urban design influences sustainable development outcomes in rapidly developing Middle Eastern cities. Thus, this study addresses the following research questions:

- How does the current gated spatial configuration of Slava City affect connectivity and spatial integration within the neighbourhood and with the surrounding urban fabric of Erbil?
- How do residents perceive the effects of limited connectivity on walkability, accessibility, and social interaction within the compound?
- To what extent can opening side gates and improving permeability enhance spatial integration and perceived access to services and movement?

Based on the theoretical relationship between spatial configuration, connectivity, and urban performance, this study formulates the following hypotheses:

H1: The gated spatial configuration of Slava City is associated with low connectivity and integration values within the street network.
H2: Improving spatial permeability through opening side gates and reconnecting blocked streets leads to increased connectivity and integration values.

2. Literature Review

Urban connectivity refers to the degree to which streets, routes, and pathways are physically linked, enabling movement and access within urban systems (Masnavi, 2011). It plays a fundamental role in shaping urban form, influencing mobility patterns, accessibility, and the overall liveability of cities. Connectivity is closely associated with the concept of permeability, which describes the extent to which an urban environment allows multiple route choices and direct movement between destinations. High levels of connectivity and permeability are widely recognized as essential components of sustainable urban form, as they support efficient movement, reduce travel distances, and enhance social interaction (Feliciotti et al., 2016; Nel et al., 2018).

In the context of sustainable urban development, connectivity is strongly linked to key outcomes such as walkability, accessibility, and social cohesion. Walkability refers to the extent to which the built environment supports pedestrian movement, while accessibility reflects the ease of reaching services and destinations. Social cohesion describes the degree of interaction, inclusion, and sense of belonging among residents within an urban environment. These outcomes are not only influenced by land-use patterns but are also significantly shaped by spatial configuration and street network structure (Cervero & Kockelman, 1997; Gehl, 2010; Handy et al., 2005), a relationship recently reaffirmed through quantified street-pattern metrics in rapidly urbanizing Iraqi contexts (Al-Saaidy et al., 2025). Restricted spatial configuration in gated high-rise developments also reduces residents' connection to nature affecting by that their social condition and their well-being (Al-Hity & Ashnaitar, 2025). Therefore, connectivity can be understood as a multidimensional construct that bridges physical urban form with social and functional urban performance. Batty (2013) demonstrated in his book The New Science of Cities that connectivity is not just a spatial attribute, but as a dynamic property of complex urban systems, embedded in movement patterns and social behaviours.

2.1. Space syntax and Spatial Configuration

The Space Syntax theory, developed by Bill Hillier and Julienne Hanson in the 1980s, provides a quantitative method for analyzing spatial configurations and their effect on human behaviour (Hillier & Hanson, 1984). It uses tools such as axial maps and integration values to evaluate how street networks influence movement, visibility, and social interaction (Hillier & Vaughan, 2007). Space Syntax has become a foundational urban design tool, linking highly integrated networks to enhanced pedestrian flow, accessibility, and spatial integration. It enables the understanding of cities as spatial systems, where elements are interconnected (Hidayat et al., 2024).

Recent research continues to enrich and expand the applicability of Space Syntax across diverse dimensions, the study by Li et al. (2025) applied Space Syntax in a Public Space Resilience (PSR) framework showing that measures like integration and connectivity strongly correlate with perceived and structural resilience during emergencies. While a systematic review by Mehrinejad Khotbehsara et al. (2025) emphasized Space Syntax as a critical method for studying social interaction and walkability, especially in plazas and seating zones. Moreover, it’s role in global urban sustainability, a study by Meng and Zhang (2024) advocate the evolution of Space Syntax for better standardized research framework that strengthens its role in sustainable urban planning. For street greenery & pedestrian dynamics, the study by Chen et al. (2025) integrated visibility graph analysis (a Space Syntax tool) with green visibility metrics to explore how street greenery influences pedestrian experience in public spaces. Further aspect to use is open vs closed-space flows, the study by Leite et al. (2024) revealed Space Syntax’s expansion into examining movement patterns in both indoor and outdoor environments, supporting Sustainable Development Goal 11 on inclusive, walkable cities. These studies confirm that spatial configuration such as gated layouts, access points, and connectivity values play a direct role in shaping social interaction, accessibility, and urban mobility outcomes.

2.2. Theoretical Framework Orientation

Collectively, the reviewed literature establishes a comprehensive foundation for analyzing the relationship between urban form and urban performance. The consistent association of spatial configuration (gate density, axial line layout, access distribution, integration values, and connectivity metrics) with outcomes such as social interaction, mobility efficiency, and urban accessibility demonstrates that urban connectivity is a multidimensional construct. As such, this study conceptualizes these spatial measures as independent variables, while urban connectivity level, social interaction patterns, accessibility, and mobility performance are framed as dependent variables, table (1).

Table1. Variables Tested, by Authors.

Independent Variables	Dependent Variables
Spatial configuration (gates, layout, access)	Urban connectivity level
Integration values (Space Syntax)	Social interaction
Connectivity values	Accessibility to services
Axial line characteristics	Urban development outcomes

2.3. Research Problem
Despite its vision as a modern, mixed-use development, Slava City faces critical short-comings in key urban sustainability indicators. These deficiencies have limited the compound’s integration with Erbil’s wider urban fabric, undermining its spatial inclusivity and functional performance. The gated nature of the development intensifies physical and social separation, raising concerns about car dependency, limited mobility, and reduced quality of urban life. Addressing these gaps is essential to align Slava City's urban form with broader sustainable development goals.

2.4. Research Objectives
The objective of this study is to evaluate the connectivity performance of Slava City, a gated residential compound in Erbil, by analyzing both spatial and social dimensions, the research aims to identify design and planning deficiencies that hinder integration with the broader urban context. The study seeks to propose evidence-based recommendations that enhance spatial cohesion, promote inclusive mobility, and strengthen the development’s contribution to sustainable urban growth in Erbil.

3. Material and Methods
This study adopts a mixed-methods approach to examine the relationship between spatial connectivity and urban performance in a gated residential compound. The methodology integrates spatial analysis, field observation, and empirical survey data to capture both configurational and experiential dimensions of connectivity. Spatial analysis was conducted using Space Syntax (DepthmapX) to evaluate connectivity and integration values of the street network under two scenarios: the existing condition and a proposed intervention involving the opening of side gates. In parallel, field observations and photographic documentation were used to assess physical barriers, street hierarchy, and movement patterns. A structured questionnaire survey was administered to 310 residents to capture perceptions of connectivity, accessibility, walkability, and social interaction. The collected data were analyzed using descriptive statistics and cross-tabulation to explore relationships between spatial conditions and resident perceptions.

3.1. Slava city
Slava City was selected as the case study for this research due to its representative characteristics as a gated residential compound within the rapidly expanding urban context of Erbil. The development exhibits a clearly defined enclosed spatial structure, limited access points, and internal street discontinuities, making it a suitable case for examining the relationship between gated urban form and connectivity performance. Its configuration provides a relevant setting to investigate how spatial restrictions influence accessibility, movement, and integration within the urban fabric.

The compound is located along the 150 Meter Road in Erbil in the northern part of the city, and is approximately 30 minutes from the city centre, figure (1). While the location offers access to major transportation routes, its relative distance from central urban areas may affect residents’ access to services and daily activities. This spatial positioning, combined with its gated layout, reinforces its relevance for analyzing connectivity limitations in contemporary residential developments. Data collection involved site visits, field observation, and photographic documentation to record the physical characteristics of the street network, including barriers, access points, and street hierarchy. A site map was used to analyze the spatial structure of the area and to support the interpretation of connectivity patterns within the compound.

3.2. General Layout and Urban Division
Slava City in Erbil is divided into two distinct residential zones, physically separated by a concrete wall and several blocked streets (marked with red nodes on the site map), figure (1). The blocked paths disturb the internal street continuity, creating two semi-independent urban clusters with no internal vehicular or pedestrian flow between them. Each side has one main access gate serving as the only connection to the surrounding city network.

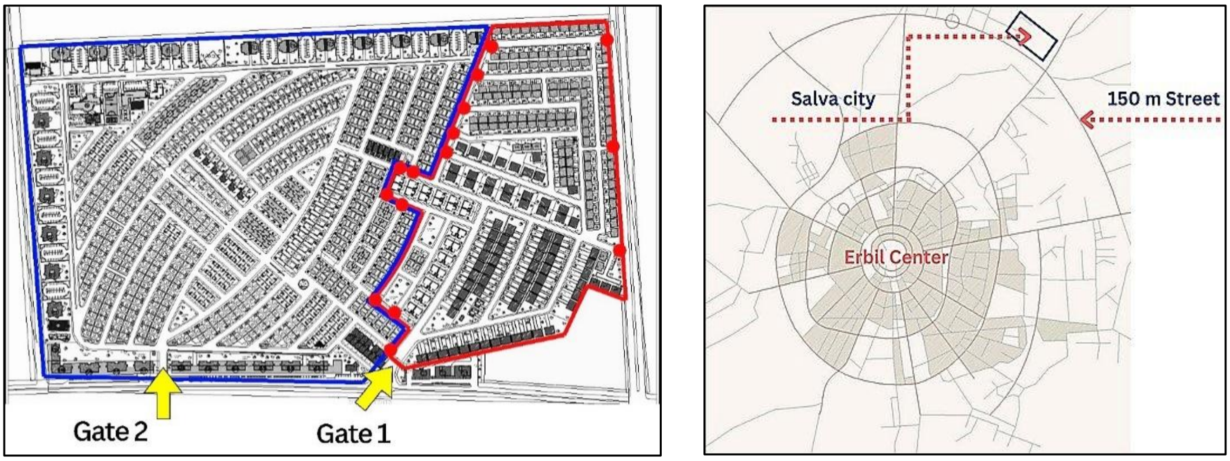


Figure 1. Slava City Site Plan and City Location, by Authors.

3.3. Street Barriers and Blockages

The red dots in the site map indicate blocked street ends, these blockages have transformed a once-integrated grid into two disconnected zones, restricting local permeability. The lack of permeability severely reduces inner-zone mobility, resulting in a fragmented urban experience and likely encouraging longer vehicle routes for basic local movement, figure (1),(2).

Figure 2. Street Blockages, by Authors.

3.4. Limited External Connectivity

Slava City has only two official gates one for each zone providing the only link to the outer urban fabric, figure (1), (2). The urban boundary is effectively walled off on all other sides, restricting urban flow and integration with the surrounding districts. This pattern isolates the community and likely limits accessibility for emergency services, public transportation, and social interaction.

3.5. Axis-Based Site Analysis

The spatial organization of Slava City reflects a clear hierarchy of street axes that directly influences movement, accessibility, and urban integration figure (3). In table (2), a detailed analysis explores the site's axis-based connectivity, highlighting variations in pedestrian flow and street usage based on observed field surveys and spatial mapping.

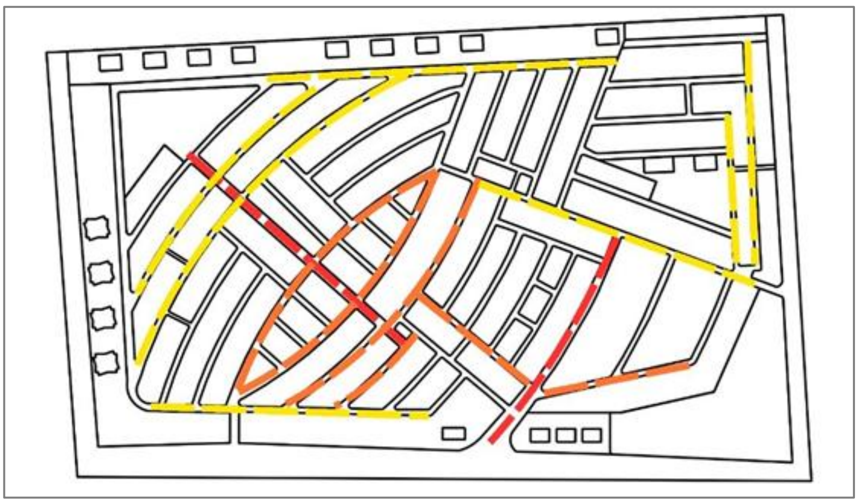


Figure 3. Street Axis, by Authors.

Table 2. Axis Connectivity Level, by Authors.

Axis Type	Color Code	Connectivity Level	Observed Usage	Functional Role
Primary Axes	Red	High	Frequent pedestrian and vehicular movement	Main internal spines linked to city gates
Secondary Axes	Orange	Moderate	Occasional pedestrian movement	Internal links between housing clusters
Supporting Axes	Yellow	Low	Sparse or irregular use	Peripheral circulation
Disconnected Streets	Unmarked	Very Low	Minimal use	Visually and spatially segregate

3.5.1. Primary Axes (Red Lines)
These represent the most connected and intensively used streets, based on field observations, figure (3), (4). These streets serve as main internal spines linking residential clusters to the two main gates. These axes enhance spatial integration, with frequent intersections that improve permeability. Residents are observed using these streets consistently throughout the day, indicating their role in facilitating functional and social connectivity.

3.5.2. Secondary Axes (Orange Lines)
These streets are moderately connected, supporting internal mobility but to a lesser extent than the red axes, figure (3). Often serve as link roads between housing blocks and the main red corridors. Field photos suggest that pedestrian flow here is limited to residents of adjacent housing units, and less attractive for cross-site movement.

3.5.3. Supporting Axes (Yellow Lines)
These form the outer boundary loops and tertiary internal paths, Figure (3). Despite being geometrically connected, observed use is sparse, especially at dead ends or near the wall separating the city's two parts. Their low connectivity and limited visual access reduce their effectiveness in supporting walkability or spontaneous interaction.

3.5.4. Disconnected and Underutilized Streets
Many lack visibility or direct connections to key routes, making them peripheral in function and integration and these are forming the rest of the city streets which affect site connectivity.

Figure 4. Streets Axis / High Connectivity**,** by Authors.

3.6. Space Syntax to Analyze Connectivity in Slava city
Space Syntax analysis was employed to evaluate the configurational properties of the street network in Slava City and to examine how its gated layout affects spatial accessibility and connectivity. The analysis was conducted in DepthmapX using an axial map, in which the street network was represented by the fewest and longest lines of sight and movement. Two scenarios were analyzed, (1) the current condition, reflecting the existing gated layout with blocked streets and only two main access gates, and (2) a proposed scenario, in which additional side gates were introduced to test the potential effect of improved permeability on spatial integration.

The analysis focused on two main syntactic measures, connectivity and integration. Connectivity was used to assess the number of directly connected axial lines for each street segment, indicating the degree of local accessibility. Integration was used to examine how easily each segment could be reached from the overall network, reflecting its relative spatial centrality. The resulting axial maps were interpreted visually and numerically, where warmer colors indicate more integrated and connected spaces, while cooler colors represent more segregated and less accessible areas. This procedure enabled a comparative evaluation of how changes in access configuration influence movement potential, permeability, and the overall spatial coherence of the site.

3.7. Survey Design and Sampling
A structured questionnaire survey was conducted to capture residents' perceptions of connectivity, accessibility, walkability, and social interaction within Slava City. This combined configurational and perceptual approach follows recent practice in the field, where axial-line Space Syntax analysis has been paired with resident surveys to identify spatial–experiential mismatches and inform targeted interventions (Li et al., 2025). The target population consisted of

adult residents living within the compound, as they are directly affected by the spatial configuration and daily movement conditions of the neighborhood.

A random sampling approach was adopted to ensure a representative distribution of responses across the study area. Participants were selected through a combination of on-site distribution and online sharing within resident groups, allowing coverage of different residential zones within the compound. A total of 310 valid responses were collected, which is considered statistically adequate for social research at a 95% confidence level. The questionnaire was structured into two main sections. The first section collected demographic information, including age, household size, and length of residence. The second section focused on the dependent variables identified in (table 1) and included a series of statements measuring residents' perceived connection to the city, accessibility to services, social interaction within the neighborhood, and the anticipated effect of opening side gates on movement and permeability.

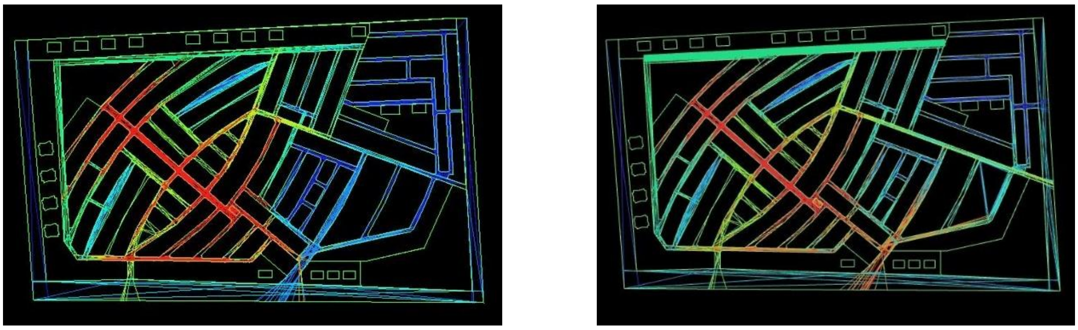
Responses were measured using a 5-point Likert scale, allowing the quantification of subjective perceptions for statistical analysis. To ensure clarity and reliability, the questionnaire was pre-tested with a small group of respondents prior to distribution, and minor adjustments were made to improve question wording and consistency. The collected data were analyzed using descriptive statistics and cross-tabulation to explore relationships between spatial conditions and residents'
perceptions.

4. Results

The spatial analysis of Slava City reveals a fragmented urban form primarily caused by the division of the compound into two physically separated zones. A concrete wall and a series of blocked streets have disrupted internal continuity, limiting circulation and forcing reliance on only two official gates as the sole connections to the external urban network. These findings indicate that Slava City limits spatial integration and restrict pedestrian permeability, and poses significant issues for promoting integrated and sustainable urban development.

4.1. Space Syntax / Depthmapx results

The axial map analysis of Slava City using Space Syntax methodology reveals a significant contrast between the existing urban configuration and the proposed scenario involving the opening of side gates to enhance connectivity. In its current state, Slava City functions as a segmented and internally divided compound, with blocked streets and only two main access points.



1- Current Axial map 2- Proposed Intervention to enhance connectivity

Figure 5. Space Syntax Analysis for Slava City.

4.1.1. Current Configuration

In its current state, Slava City functions as a segmented and internally divided compound, figure (5-1) with blocked streets and only two main access points. The axial map demonstrates:

-Moderate integration values concentrated around the central spine, with the peripheries exhibiting poor connectivity.
-Several axis appear visually and spatially disconnected, highlighting a limited permeability internally and externally.
-This configuration restricts movement within and across the compound, negatively affecting walkability, accessibility, and external integration with the wider Erbil road network.
These low integration and connectivity values concentrated around a single internal spine with the poor peripheral connectivity observed under the current gated layout support H1.

4.1.2. Proposed Intervention: Opening Side Gates

In the proposed scenario, the axial map was re-analyzed after introducing new openings along the compound's periphery, figure (5-2). The changes indicate:

-A wider distribution of integration values, extending beyond the central zone to include side streets and lines.
- New axial lines connect Slava City to adjacent road networks, especially along its northern and edges, figure (5-2).
-The spatial network becomes more continuous and legible, enhancing accessibility and permeability across the site.
-This results in improved flow, reduced segregation, and increased urban coherence.

-The Space Syntax analysis demonstrated that opening the two side gates significantly increased both connectivity and integration values, creating more accessible and interconnected street segments enhancing spatial permeability and better linking the site to the surrounding urban fabric.
-In table (3) below, the connectivity value for example for reference line 705 f significantly increased from 112 to 333 after opening the side gates, indicating a substantial improvement in spatial integration. Additionally, the node count, integration and total connectivity increased reflecting an enhancement in accessibility and interaction within the surrounding network.

Table 3. Connectivity Improvement.

Ref Number (705)	Connectivity	Line length	Node count	Integration	Total connectivity
After opening side gates	333 ↑	0.814648 ↑	736 ↑	12.7132	129672 ↑
Before opening side gates	112	0.122247	514	8.23965	110133

The Space Syntax axial analysis underscores how simple spatial interventions such as opening side gates can significantly alter the connectivity profile of a residential com-pound. Below in table (4) is a comparative analysis between two scenarios:

Table 4. Space Syntax Findings.

Indicator	Current Situation	Proposed Scenario (Gates opened)
Number of Access Gates	2	4 or more
Street Segregation (Visual)	High	Moderate to Low
Integration Core Coverage	Central Only	Central + Periphery
External Connectivity	Poor	Moderate
Internal Navigation	Disrupted / Disjointed	Continuous and Walkable

4.2. Statistical results for Connectivity

The connectivity indicator for Slava City was assessed using responses from 310 residents. This indicator focuses on residents' sense of spatial and functional connection to the broader urban fabric of Erbil. The evaluation covers perception of city linkage, social interaction potential, and the influence of commercial activity and boundary permeability on connectivity levels.

4.2.1. Demographic Overview

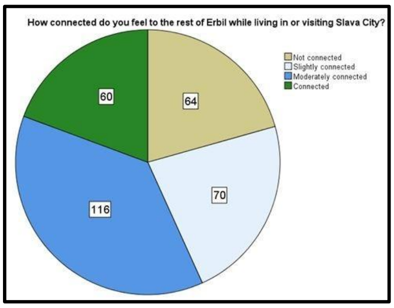
Among the respondents, household size varied, with the majority (210 residents) living in households of 2–3 people, followed by 43 residents in households of 4–5 members, 32 in households of 6 or more, and 19 living alone. In terms of age distribution, the sample was primarily composed of residents aged 25–34 (189 individuals), followed by those aged 35–44 (108 individuals), and a smaller portion aged 45–54 (13 individuals). Regarding the duration of residence in Slava City, 139 respondents had lived in the area for 1–3 years, 101 for less than one year, and 70 for 4–6 years. This demographic profile provides a balanced representation of recent and mid-term residents across different age groups, contributing to the reliability of the connectivity assessment.

4.2.2. Perceived Connection to the City of Erbil

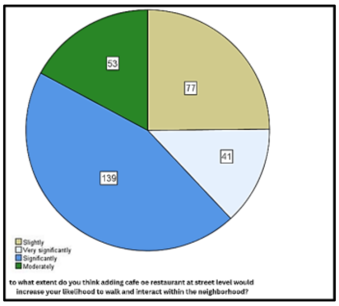
The survey results suggest that many residents experience a limited sense of integration with the rest of Erbil. As illustrated in figure (6-1), the largest proportion of respondents (116 individuals) reported feeling moderately connected, while only 60 stated they felt connected. Additionally, 70 reported being slightly connected and 64 indicated no connection at all. These findings reflect a notable disconnect between Slava City and the urban systems surrounding it, likely due to physical barriers, limited entry points, and a lack of urban continuity.

4.2.3. Influence of Commercial Frontage on Interaction

The data in figure (6-2), highlights the role of street-level activity in promoting connectivity and social vibrancy. When asked about the potential impact of adding shops, cafés, and restaurants at street level, the majority (139 respondents) indicated it would significantly increase their likelihood to walk and interact within the neighborhood. A further 77 responded slightly, 53 moderately, and 41 very significantly. This confirms that urban connectivity is not solely spatial but also experiential, and highly dependent on the presence of engaging and functional public-facing infrastructure.



1- Perceived Connectivity to Erbil Among Slava City



2- Impact of Commercial Frontage on Neighborhood

Figure 6. Statistical Result by Residents' Survey.

4.2.4. Connectivity and Side Gate Access

The third dimension of the connectivity assessment is the impact of reopening side gates, figure (7), (185) residents (nearly 60%) anticipate a strong impact, 111 foresee a moderate impact, and only 14 reported a slight impact. The data supports the idea that connectivity improvements through perimeter integration can enhance residents' sense of inclusion and navigability.

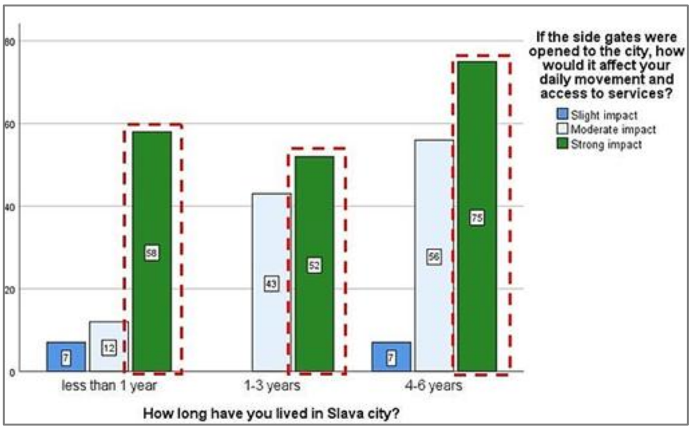


Figure 7. Anticipated Impact of Reopening Side Gates on Connectivity.

4.2.5. Residency Duration and Perceived Gate Impact

To further explore this issue, a cross-tabulation analysis was conducted between how long residents have lived in Slava City and how they believe opening the side gates would affect their movement and service access. The cross-tabulated results in Table (5), reveal a clear trend: respondents who have lived in the compound longer are more likely to perceive a strong impact from opening the gates. For example, among those who have lived in Slava for 4–6 years, 75 selected strong impact; similarly, 52 long-term residents in the 1–3-year group echoed this. These findings suggest that longer residency correlates with greater awareness of the site's limitations and a stronger desire for spatial integration.

Table 5. Residency Duration vs. Perceived Impact of Opening Side Gates.

Crosstabulation		If the side gates were opened to the city, how would it affect your daily movement and access to services?			
		Slight impact	Moderate impact	Strong impact	Total
How long have you lived in Slava city?	less than 1 year	7	12	58	77
	1-3 years	0	43	52	95
	4-6 years	7	56	75	138
Total		14	111	185	310

5. Discussion

The results of this study clearly demonstrate that the spatial layout of Slava City deters internal mobility and limits its connectivity with the surrounding urban fabric. The street offers limited connectivity inside the city, which reduce permeability and inhibit walkability, revealing a spatial form that contradicts the principles of inclusive, efficient, and sustainable urban development. Thus, connectivity as a core indicator of urban sustainability is critically compromised in Slava City's current configuration. The Space Syntax results vividly demonstrate how the current configuration results in moderate integration values concentrated only around a central internal spine, leaving peripheries poorly connected. Critically, the proposed intervention of opening side gates dramatically improves both connectivity and integration values across the compound, leading to more accessible and interconnected street segments, supporting H2. This technical finding is paralleled by resident perceptions, with nearly 60% anticipating a "strong impact" from opening side gates, a pattern that appears more pronounced among longer-term residents. The survey also highlighted the significant role of commercial frontage in enhancing neighborhood interaction, suggesting that physical barriers and a lack of mixed-use public spaces deter social vibrancy.

5.1. Comparison with Previous Studies

The present findings are consistent with Durgut and Yildiz Ozkan (2022), who demonstrated that spatial connectivity plays a significant role in shaping pedestrian movement and the use of urban space. Yang & Qian, (2022) showed that changes in spatial configuration can significantly influence pedestrian flows in urban redevelopment scenarios, highlighting the importance of network structure in shaping accessibility and urban vitality. Hammad et al. (2025) found that gated communities in Amman exhibit low integration and high step-depth values, indicating restricted accessibility and weakened social interaction with their surroundings. In line with these studies, the results from Slava City indicate that limited permeability and restricted access points reduce both spatial integration and residents' perceived ease of movement.

5.2. Implications for the Field

This research shows that street connectivity is a key factor in urban sustainability, especially in rapidly growing cities like Erbil. Using Slava City as a case study, it demonstrates how gated, enclosed designs reduce integration, accessibility, and social cohesion. The findings emphasize the need for permeability-driven planning that prioritizes street hierarchy, pedestrian access, and spatial integration. By combining spatial metrics with resident feedback, the study highlights how improving micro-scale connectivity can strengthen broader urban resilience and serve as a model for other residential compounds.

5.3. Limitations

Although this study provides valuable insights into spatial connectivity in Slava City, it is limited by its focus on a single case study, which may restrict the generalizability of the findings. Additionally, the analysis relies primarily on perceptual data from residents and configurational metrics, without incorporating longitudinal data or real-time movement tracking. The survey findings are presented descriptively to contextualize the spatial results, rather than as a statistically tested relationship between perceived and measured connectivity, a direction left for future research. Future research could expand the analysis by including multiple case studies and integrating advanced mobility data to strengthen empirical validation.

5.4. Future Research Directions

Additional research is needed to explore how different types of urban design interventions can reinforce connectivity in gated housing complexes. Research on the open and gated neighborhoods in Erbil could prove invaluable in furthering our understanding of the best ways to integrate and interact while also achieving urban sustainability.

6. Conclusions

The study found that the fragmentation of Slava City limits internal mobility and pedestrian integration. The research, through axis-based analysis and field observations, Space syntax and residents feedback adds to a larger framework of understanding connectivity as a fundamental component of urban sustainability toward gated communities. These findings emphasize the need for permeability-oriented design strategies to foster more equitable and resilient urban spaces. This study provides a practical approach for planning moving forward and highlights the need for additional studies on the urbanization that connectivity may bring.

6.1 Recommendations

- Encourage ground-floor activity (shops, restaurants) to create more social interaction that attracts pedestrian.
- Reopen some previously blocked streets to reconnect the two zones and improve internal circulation.
- Open the two side gates to strengthen spatial connectivity with the city, figure (8), to improve traffic distribution, and encourage movement through the site rather than around it.
- Create safe, continuous cycling lanes that interconnect the site's major destinations with the surrounding city.
- Create Child-Friendly Public Spaces within public squares and parks to support families and social life.
- Provide benches and movable seating arranged at conversational angles to support spontaneous social interactions.

Figure 8. Proposed site plan.

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Conflict of Interests
The authors declare no conflict of interest.

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Data Availability Statement
Data available on request due to privacy/ethical restrictions.

Institutional Review Board Statement
All ethical standards were rigorously observed, including assurances of confidentiality, voluntary participation, and the right to withdraw from the study at any time without penalty.

CRediT Author Statement
Shahad Ashnaitar: Writing - original draft; Methodology; Visualization; Software; Formal analysis. Rebwar I. Ibrahim: Supervision; Project administration; Validation; Roles. Mustafa Khayyat: Writing - review & editing; Resources; Investigation; Data curation. All authors have read and approved the final version of the manuscript.

References

Al-Hity, N., & Ashnaitar, S. (2025). Enhancing well-being in high-rise residential buildings by biophilic design in Erbil, Iraq. Journal of Salutogenic Architecture, 4(1), 112–130. https://doi.org/10.38027/jsalutogenic_vol4no1_7

Al-Saaidy, H. J. E., Alobaydi, D., & Abdullah, S. F. K. (2025). Street networks and urban sustainability by quantifying connectivity, accessibility, and walkability for resilient cities. Civil Engineering Journal, 11(6), 2421–2439. https://doi.org/10.28991/cej-2025-011-06-015.

Batty, M. (2013). The new science of cities. MIT Press. https://doi.org/10.7551/mitpress/9399.001.0001

Castro Sánchez, L. E., & Delgado Ramos, G. C. (2025). Sustainable mobility indicators based on micro-scale urban form: The case of Monterrey City, Mexico. Frontiers in Sustainable Cities, 7, Article 1605835. https://doi.org/10.3389/frsc.2025.1605835

Cervero, R., & Kockelman, K. (1997). Travel demand and the 3Ds: Density, diversity, and design. Transportation Research Part D: Transport and Environment, 2(3), 199–219. https://doi.org/10.1016/S1361-9209(97)00009-6

Chen, M., Liu, Y., Liu, F., Chadha, T., & Park, K. (2025). Measuring pedestrian-level street greenery visibility through space syntax and crowdsourced imagery: A case study in London, UK. Urban Forestry & Urban Greening, 105, 128725. https://doi.org/10.1016/j.ufug.2025.128725

Durgut, Z. C., & Yildiz Ozkan, D. (2022). The effects of spatial connectivity on pedestrian movement and space usage in waterfront areas. In A. van Nes & R. E. de Koning (Eds.), Proceedings of the 13th International Space Syntax Symposium (SSS 2022). Western Norway University of Applied Sciences.

Feliciotti, A., Romice, O., & Porta, S. (2016). Design for change: Five proxies for resilience in the urban form. Open House International, 41(4), 23–30. https://doi.org/10.1108/OHI-04-2016-B0004

Gehl, J. (2010). Cities for people. Island Press.

Hammad, A., Li, M., & Vrcelj, Z. (2025). Space Syntax Analysis of Gated Communities in Jordan: Examining urban connectivity and Social impact. Sustainability, 17(2), 599. https://doi.org/10.3390/su17020599.

Handy, S., Cao, X., & Mokhtarian, P. (2005). Correlation or causality between the built environment and travel behavior? Evidence from Northern California. Transportation Research Part D: Transport and Environment, 10(6), 427–444. https://doi.org/10.1016/j.trd.2005.05.002

Hidayat, A., Mustofa, U., & Maulana, M. A. (2024). Spatial analysis of road network integration using space syntax in residential areas. In Proceedings of the 5th Borneo International Conference (BICAME 2024): Symposium on Digital Innovation, Sustainable Design and Planning (DSP). Atlantis Press. https://doi.org/10.2991/978-2-38476-329-0_4

Hillier, B., & Hanson, J. (1984). The social logic of space. Cambridge University Press. https://doi.org/10.1017/CBO9780511597237

Hillier, B., & Vaughan, L. (2007). The city as one thing. Progress in Planning, 67(3), 205–230. https://doi.org/10.1016/j.progress.2007.03.001

Jabareen, Y. R. (2006). Sustainable urban forms: Their typologies, models, and concepts. Journal of Planning Education and Research, 26(1), 38–52. https://doi.org/10.1177/0739456X05285119

Jenks, M., & Jones, C. (Eds.). (2010). Dimensions of the sustainable city. Springer.

Leite, P. W. da L., Silva, C. C. O. de A., Moro, L. D., Bodah, B. W., Mores, G. de V., Piccinato Junior, D., Engel, A., Santosh, M., & Neckel, A. (2024). Space syntax as an expression of science on user flows in open and closed spaces aimed at achieving the Sustainable Development Goals: A review. Architecture, 4(1), 170–187. https://doi.org/10.3390/architecture4010011

Li, Q., Yang, Z., Cui, J., Wu, X., Liu, J., Li, W., & Liu, Y. (2025). Age-Friendly Public-Space retrofit in Peri-Urban villages using space syntax and exploratory factor analysis. Buildings, 15(13), 2219. https://doi.org/10.3390/buildings15132219.

Li, Y., Wang, M., Wang, B., & Liang, Y. (2025). Bridging subjective and objective dimensions of resilience: A space syntax approach to analyzing urban public spaces. Sustainability, 17(13), Article 5937. https://doi.org/10.3390/su17135937

Masnavi, M. R. (2011). Sustainable urban forms design and planning strategies: Compact city, urban sprawl and mixed-use development in theory and practice (1st ed.). LAP Lambert Academic Publishing.

Mehrinejad Khotbehsara, E., Yu, R., Somasundaraswaran, K., Askarizad, R., & Kolbe-Alexander, T. (2025). The walkable environment: A systematic review through the lens of space syntax as an integrated approach. Smart and Sustainable Built Environment. Advance online publication. https://doi.org/10.1108/SASBE-02-2024-0049

Meng, D., & Zhang, J. (2024). The evolution of space syntax over the past two decades: Evidence from China. Journal of Asian Architecture and Building Engineering. Advance online publication. https://doi.org/10.1080/13467581.2024.2399739

Mobaraki, A., Nikoofam, M., & Mobaraki, B. (2025). The nexus of morphology and sustainable urban form parameters as a common basis for evaluating sustainability in urban forms. Sustainability, 17(9), 3967. https://doi.org/10.3390/su17093967

Nel, D. H., Higgins, C. D., & Bruyns, G. (2018). Urban design, connectivity and its role in building spatial resilience. In XXV International Seminar on Urban Form 2018 Urban Form and Social Context: from traditions to newest demands http://hdl.handle.net/10397/81444

Neuman, M. (2005). The compact city fallacy. Journal of Planning Education and Research, 25(1), 11–26. https://doi.org/10.1177/0739456X04270466

Yang, C., & Qian, Z. (2022). Street network or functional attractors? Capturing pedestrian movement patterns and urban form with the integration of space syntax and MCDA. URBAN DESIGN International, 28(1), 3–18. https://doi.org/10.1057/s41289-022-00178-w.